

Project : \_\_\_\_\_ Prepared by: \_\_\_\_\_ Date : \_\_\_\_\_  
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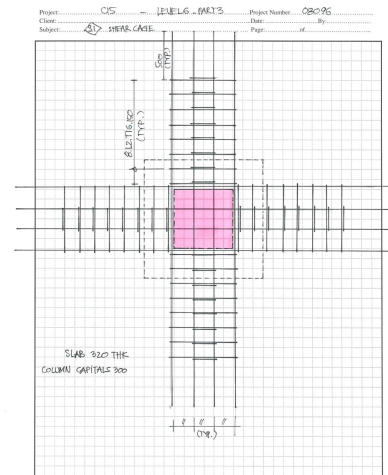
**This spreadsheet illustrates the punching shear check for Level 06 - column at grid K1-30 (shear cage S1)**

The punching shear resistance for section in flexure is given in Technical report TR43 (section 6.11.2)

Concrete  $f_{cu} := 45\text{MPa}$

Reinforcement  $f_y := 460\text{MPa}$

Design shear  $V_{\text{design}} := 3180\text{kN}$



**Transverse direction**

Panel width = 8.4m

Thanks to capitals, the equivalent section at critical perimeter is 420D (320+100) x 1000W (600+2\*200)

Effective depth  $d_{tr} := 420\text{mm} - (25\text{mm} + 16\text{mm} + 8\text{mm})$   $d_{tr} = 371\cdot\text{mm}$

Length of critical perimeter perpendicular to transverse direction

$b_{tr} := 1000\text{mm} + 2 \cdot 1.5 \cdot (d_{tr} - 100\text{mm})$   $b_{tr} = 1813\cdot\text{mm}$

Area reinforcement provided (8T20 + 3 bonded tendons 5s)

$As_{tr} := 8T20 + \frac{3 \cdot 5 \cdot 110\text{kN}}{f_y}$   $As_{tr} = 6099\cdot\text{mm}^2$

Width over which reinforcement provided in width

$b_{tr2} := 1000\text{mm} + 2 \cdot 1.5 \cdot 320\text{mm}$   $b_{tr2} = 1960\cdot\text{mm}$

Area of reinforcement provided in width, btr

$As_{pv} := \frac{b_{tr}}{b_{tr2}} \cdot As_{tr}$   $As_{pv} = 5642\cdot\text{mm}^2$

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Concrete shear capacity

$$k_1 := \min\left(\frac{100A_{spv}}{b_{tr} \cdot d_{tr}}, 3\right) \quad k_1 = 0.839$$

$$k_2 := \max\left(1, \frac{400\text{mm}}{d_{tr}}\right) \quad k_2 = 1.078$$

$$\nu_c := \frac{0.79}{1.25} \cdot k_1^{\frac{1}{3}} \cdot k_2^{\frac{1}{4}} \cdot \left(\frac{f_{cu}}{25\text{MPa}}\right)^{\frac{1}{3}} \cdot \text{MPa} \quad \nu_c = 0.739 \cdot \text{MPa}$$

Effects of prestress

$$e_{tr} := \frac{-420\text{mm}}{2} + 45\text{mm} + 25\text{mm} \quad e_{tr} = -140 \cdot \text{mm}$$

For Span width 8.4m

Prestress force/ tendon after all losses = 110kN

Number of tendon across panel width = 7\*5=35

Prestress force across panel width

$$P := 35 \cdot 110\text{kN} \quad P = 3850 \cdot \text{kN}$$

Prestress force across critical perimeter, P1

$$P1 := 0.5 \cdot P \quad P1 = 1925 \cdot \text{kN}$$

Area of concrete across panel width (8.4m)

$$A_c := 0.32\text{m} \cdot 8.4\text{m} \quad A_c = 2.688 \text{m}^2$$

$$Z_t := b_{tr} \cdot \frac{(320\text{mm})^2}{6} \quad Z_t = 0.031 \cdot \text{m}^3$$

$$M_0 := 0.8 \cdot P \cdot \frac{Z_t}{A_c} - 0.8 \cdot P1 \cdot e_{tr} \quad M_0 = 251 \cdot \text{kNm}$$

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#### Applied Moments and Shear Forces

$$M_{tr} := 1350 \text{ kNm}$$

$$V_{tr} := 1380 \text{ kN}$$

$$V_{cr_{tr}} := \nu_c \cdot b_{tr} \cdot d_{tr} + M_0 \cdot \frac{V_{tr}}{M_{tr}} \quad V_{cr_{tr}} = 754 \cdot \text{kN} \quad M_0 \cdot \frac{V_{tr}}{M_{tr}} = 257 \cdot \text{kN}$$

#### Longitudinal direction

Panel width = 8.4m

$$\text{Effective depth} \quad d_{lg} := 420 \text{ mm} - (25 \text{ mm} + 8 \text{ mm}) \quad d_{lg} = 387 \cdot \text{mm}$$

Length of critical perimeter perpendicular to longitudinal direction

$$b_{lg} := 1000 \text{ mm} + 2 \cdot 1.5 \cdot (d_{lg} - 100 \text{ mm}) \quad b_{lg} = 1861 \cdot \text{mm}$$

Area reinforcement provided (8T20 + 3 bonded tendons 5s)

$$A_{s_{lg}} := 8T20 + \frac{3 \cdot 5 \cdot 110 \text{ kN}}{f_y} \quad A_{s_{lg}} = 6099 \cdot \text{mm}^2$$

Width over which reinforcement provided in width

$$b_{lg2} := 1000 \text{ mm} + 3 \cdot 320 \text{ mm} \quad b_{lg2} = 1960 \cdot \text{mm}$$

Area of reinforcement provided in width, btr

$$A_{s_{lg1}} := \frac{b_{lg}}{b_{lg2}} \cdot A_{s_{lg}} \quad A_{s_{lg1}} = 5791 \cdot \text{mm}^2$$

Concrete shear capacity

$$k_1 := \min \left( \frac{100 A_{s_{lg1}}}{b_{lg} \cdot d_{lg}}, 3 \right) \quad k_1 = 0.804$$

$$k_2 := \max \left( 1, \frac{400 \text{ mm}}{d_{lg}} \right) \quad k_2 = 1.034$$

$$\nu_c := \frac{0.79}{1.25} \cdot k_1^{\frac{1}{3}} \cdot k_2^{\frac{1}{4}} \cdot \left( \frac{f_{cu}}{25 \text{ MPa}} \right)^{\frac{1}{3}} \cdot \text{MPa} \quad \nu_c = 0.721 \cdot \text{MPa}$$

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Effects of prestress

$$e_{lg} := \frac{-420\text{mm}}{2} + 25\text{mm} + 25\text{mm}$$

$$e_{lg} = -160\text{mm}$$

For Span width 8.4m

Prestress force/ tendon after all losses = 110kN

Number of tendon across panel width = 7\*5=35

Prestress force across panel width

$$P_{lg} := 35 \cdot 110\text{kN}$$

$$P_{lg} = 3850\text{ kN}$$

Prestress force across critical perimeter, P1

$$P1_{lg} := 0.6 \cdot P$$

$$P1_{lg} = 2310\text{ kN}$$

Area of concrete across panel width (8.4m)

$$A_{c.lg} := 0.32\text{m} \cdot 8.4\text{m}$$

$$A_{c.lg} = 2.688\text{ m}^2$$

$$Z_{t.lg} := b_{lg} \cdot \frac{(320\text{mm})^2}{6}$$

$$Z_{t.lg} = 0.032\text{ m}^3$$

$$M_{0.lg} := 0.8 \cdot P_{lg} \cdot \frac{Z_{t.lg}}{A_{c.lg}} - 0.8 \cdot P1_{lg} \cdot e_{lg}$$

$$M_0 = 251\text{ kNm}$$

Applied Moments and Shear Forces

$$M_{lg} := 1550\text{kNm}$$

$$V_{lg} := 1370\text{kN}$$

$$V_{cr_{lg}} := \nu_c \cdot b_{lg} \cdot d_{lg} + M_0 \cdot \frac{V_{lg}}{M_{lg}}$$

$$M_0 \cdot \frac{V_{lg}}{M_{lg}} = 222\text{ kN}$$

$$V_{cr_{lg}} = 741\text{ kN}$$

Total shear resistance

$$V_{cr} := V_{cr_{tr}} + V_{cr_{lg}}$$

$$V_{cr} = 1495\text{ kN}$$

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### **Applied shear force**

Longitudinal direction provides worst condition

$$V_{\text{eff}} := V_{\text{design}} \cdot \left( 1.0 + 1.5 \cdot \frac{M_{\text{lg}}}{b_{\text{lg}} \cdot V_{\text{lg}}} \right) \quad V_{\text{eff}} = 6080 \cdot \text{kN}$$

$$\text{Check}_{\text{shear}} := \begin{cases} \text{"provide shear cage"} & \text{if } V_{\text{eff}} \geq V_{\text{cr}} \\ \text{"shear cage not required"} & \text{otherwise} \end{cases}$$

$\text{Check}_{\text{shear}} = \text{"provide shear cage"}$
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Asv required

$$A_{\text{sv}} := \frac{(V_{\text{eff}} - V_{\text{cr}})}{0.95 \cdot f_y} \quad A_{\text{sv}} = 10493 \cdot \text{mm}^2$$

Using T16 double legs links, number required

$$\text{No} := \frac{A_{\text{sv}}}{2T16} \quad \text{No} = 26$$

Maximum spacing permitted = 1.5d

Place 2x8 = 16 Nos at 150 spacing no on perimeter of 0.5d from the column face.

Place 6x8 = 48 Nos at 150 spacing no on perimeter of 2.25d from the column face.